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AN/FPS-112(XN-1) Detailed Test and Evaluation Plan

[Unclassified Title]

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(U) A one-year Test and Evaluation (T&E) Plan is presented to identify the technical performance characteristics and operational capabilities of the AN/FPS-112 (XN-1) radar (formerly known as CHECKROTE III) and to demonstrate its usefulness in the naval mission of Fleet air defense.

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ABSTRACT
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A one-year Test and Evaluation (T&E) Plan is presented to identify the technical performance characteristics and operational capabilities of the AN/FPS-112(XN-1) radar (formerly known as CHECKROTE III) and to demonstrate its usefulness in the naval mission of Fleet air defense.

AN/FPS-112(XN-1) OTH RADAR DETAILED TEST AND EVALUATION PLAN

(Secret Title)

AN/FPS-112(XN-1) DETAILED TEST AND EVALUATION PLAN

(Unclassified Title)

1.0 (U) INTRODUCTION

1.1 (S/NF) The AN/FPS-112(XN-1) Radar Test and Evaluation (T&E) Program is intended to demonstrate the radar capabilities as a monostatic, HF, over-the-horizon (OTH) radar and its usefulness to the fleet for surveillance and tactical uses in the area of fleet air defense (FAD). The capability to provide secure communication from the radar to a remote site by means of the broadcast MODEM located remotely, and to provide covert communication from the remote site to the AN/FPS-112(XN-1) radar site via the VEDEE, also located at the remote site, will be demonstrated. Future use of this radar for a bistatic system is scheduled subsequent to the monostatic radar T&E program.

1.2 (U) The following Test and Evaluation (T&E) plan is based upon the assumptions that the radar system is capable of performing the designated tasks, that the radar system is operable a high percent of the time with a minimum of maintenance time, and that it is supported and operated by a sufficient number of qualified personnel. The actual capability of the system remains to be demonstrated as a part of the test program. Some modification of the T&E plan may be required after the performance is determined or if the other assumptions are invalid.

1.3 (U) Even though a number of the paragraphs in this test plan are marked as unclassified it should be noted that test procedures generated and/or data gathered in response to the same paragraphs will in many cases be classified secret or confidential.

1.4 (U) This test plan was originally issued in draft form on 16 July 1973 and was based upon a one-year T&E program throughout FY 74. A delay in the completion of the AN/FPS-112(XN-1) radar plus an added requirement that satisfactory radar performance be demonstrated to DDR&E before deferred FY 74 problem funds would be restored, caused a change to be made in the planned sequence of tests. However, the testing was not completed in any of the planned areas so a final copy of the Test Plan was issued as an NRL Technical Memo on 27 August to provide a specific set of requirements with identified paragraph numbers to the contractor so that he could write the detailed procedures that were required from him. The Test Plan is now being published to provide required information to additional assisting agencies in a documented form.

2.0 (U) OPERATIONAL CHECKOUT

2.1 (U) Function Checkout

2.1.1 (U) Exercise all radar modes of transmission, processing, and all displays and verify proper operation for all functions. Use the calibrate signal as well as real input signals.

2.2 (U) Clutter and Target Observations

2.2.1 (S) Illuminate a representative set of coverage areas by suitable selections of frequency, azimuth steering, and vertical phasing. Three areas such as Puerto Rico, Eastern Cuba, and Miami will be considered to be representative for this test. Note the clutter returns in each area. Check the MTI for clutter removal.

2.2.2 (U) Perform aircraft target detections. Correlate detections against known flights where possible.

2.3 (U) Displays

2.3.1 (U) Observe operation of each of the displays. Compare the tracker display with manual tracking of both high and low (SNR) Signal-to-Noise Ratio target returns.

2.4 (U) Other Parameter Changes

2.4.1 (U) Operate with several values of Pulse Repetition Intervals (PRI).

2.4.2 (U) Process using the Pulse Doppler Analyzer (PDA) with coded pulse. Record SNR with various coherent integration times.

2.4.3 (U) Utilize the 31 and 63 bit codes with the correlator. Record SNR changes.

2.4.4 (U) Operate with simple variable pulse lengths using the PDA analyzer. Record SNR changes to determine duty factor tradeoffs vs establishment of track.

2.4.5 (U) Check the operational agility - switching times and convenience in varying operating parameters.

2.5 (U) Tracker

2.5.1 (U) Demonstrate the tracker operation with the calibrate signal injected into the receiver. This will be tested for target simulation within the capability of the calibrator.

2.6 (U) Train operators in the use of the radar. Set up operating procedures to assure consistency in use of the system Establish formats and initiate logs as described in subsequent sections.

2.7 (U) Review any problems experienced with the checkout operation. Initiate corrections where feasible within the scope of the problem, and make recommendations for modifications deemed necessary that involve long implementation times and/or added funding.

3.0 (U) SYSTEM CALIBRATION

3.1 (U) Antenna

3.1.1 (U) The system transmit and receive antenna patterns will be determined for representative selections of steer angles, phasing selection, and operating frequency. These measurements will be performed by the Rome Air Development Center and will be accomplished by a series of aircraft flights. These measurements are an addition to the data obtained from the antenna pattern measurement tests in accordance with ITT-EPL, TS 112 Test Program.

3.2 (U) Transmitter

3.2.1 (U) Transmitter characteristics shall be determined. Power output shall be initially checked for all HPA outputs during fixed frequency operation, and measurements shall cover the entire frequency band. Spectral characteristics of the actual transmitted output (obtained from a pickup antenna) shall be measured to determine the actual spectral width and character of the output signal, the harmonic content, spurious and 60-Hz levels, and noise level. Photographs of the spectral response shall be made available for future reference.

3.3 (U) System Sensitivity

3.3.1 (U) Determine loop gain ($P_t \cdot G_t \cdot G_r$) and check with the sea echo return signal and the beacon returns when available. Compare calculated values of sea return signal levels with the system calibrate signal levels when set to a comparable amplitude.

3.3.2 (U) Measure operational dynamic range and the minimum detectable signal (MDS) for a representative sample of illumination areas. Determine the limiting factor of the MDS.

3.4 (U) System Resolution and Accuracy

3.4.1 (U) Obtain range resolution by dual input signals of equal amplitude. Determine also discernibility in range separation for dual input signals differing in amplitude by 3 to 60 dB. One of the dual inputs may be a target and the other the calibrator. Measure range side lobes for several parameter choices, e.g., such as analysis filter bandwidth changes.

3.4.2 (U) Determine velocity (doppler) resolution first with two equal amplitude signals. Repeat test with signals differing in amplitude to measure velocity side lobes. Determine limits with operating parameter changes. Check the doppler readout accuracy compared to calibrate signal.

3.4.3 (U) Measure the accuracy of the azimuth (monopulse) readout for three frequencies representative of the coverage vs steer angle and SNR. Real targets should be used where possible. Check for azimuth resolution when targets of opportunity permit (or alternatively, one target may be compared with the calibrate signal).

3.5 (U) Displays

3.5.1 (U) Check the readout calibration of all display formats and digital readouts. Use the calibrate signal when convenient. Establish operating levels and threshold levels for the display inputs and calibrate the threshold and level controls. Observe the interactive display for the tracker cursor and compare the readout with the displayed position.

3.6 (U) Ground Range Calibration

3.6.1 (U) Devise a method to calculate ground range from the radar indications to provide values in near real time for plotting purposes. Determine also the accuracy of the calculation.

3.7 (U) Start-up and Equipment Performance Check

3.7.1 (U) Establish a checkout procedure for use each time the radar is operated to insure that the performance limits are known. For example, limits of power output should be chosen and recorded and any deviation made known to the operation in real time. Logs of the checkout data are to be retained for assessing operation of the radar at a later time, and establishing maintenance procedures and recommending modifications.

4.0 (U) RADAR MANAGEMENT

4.1 (U) General

4.1.1 (U) The development of radar management techniques although begun during the operational checkout and calibration periods will be emphasized for the next two-month period.

4.2 (U) Propagation and Frequency Management

4.2.1 (U) Propagation management and frequency selection will require: (1) development of path predictions for planning applications, (2) clutter mapping to establish locations of known land areas or land-sea boundaries at sufficient points within the coverage area to insure correct area of

illumination and azimuth/range calibration, (3) location and recording of radar azimuth known signal sources to identify ionospheric tilt problems, (4) propagation mode identification techniques, (5) resolution of multipath problems, and (6) selection of frequencies for coverage requirements with minimum noise and interference.

4.3 (U) Other Operating Parameters

4.3.1 (U) Supply a quick means to select the other optimum radar operating parameters such as the most suitable waveform, processing modes, and integration times. This will probably take the form of a tabulated list as an operator aid for observing specific target types at specific times and at given locations. Short notice may be provided to the operator for setting the radar to detect a special event such as a missile launch, and a well-considered parameter table should be on hand. Utilize the calibration signal to compare with on-line signal returns for improving or confirming the measurement accuracy of amplitudes, doppler frequencies, azimuths, etc. Insure that HDR recordings include calibration signals suitably adjusted in range, velocity, azimuth, and amplitude to assure accuracy of playback data readout without interfering with desired targets. Provide for HDR recordings to be made of all significant radar operating periods. Assess the system performance for the various operating parameter selections and provide a means to monitor the performance.

4.4 (U) Displays

4.4.1 (U) Determine which displays are best suited for the radar operator's use and for fleet use. Assess performance versus adjustment of display and threshold levels. Select the display formats and tracking methods in the best interest of the user's requirements.

4.5 (U) Output Data

4.5.1 (U) Establish procedures for handling the radar output data.

4.5.2 (U) Implement a procedure for the on-line, real-time conversion of radar output data to geographical locations and target parameters.

4.5.3 (U) Devise a technique for presenting target data of interest on a plotting board. Install the necessary communication with the plotter and determine the best background presentations to show the target tracks.

4.5.4 (U) Establish the procedure for the timely reporting of significant radar detections and tracks to outside users.

4.6 (U) Procedures and Records

4.6.1 (U) Implement the system checkout and calibration procedure and set up the formats for logging operating times, parameters, etc.

4.7 (U) Operational Scheduling and Coordination

4.7.1 (U) A long-range schedule shall be prepared as a part of the test procedure to reflect the overall requirements of the T&E Plan.

4.7.2 (U) A detailed operational schedule shall be prepared each month for the next month's operations. The schedule shall be coordinated with all interested agencies.

4.7.3 (U) Requests for dedicated and/or cooperating aircraft or ship operations shall be made in a timely fashion to cooperating agencies. Post-operational supporting data requirements shall be included in the requests.

4.8 (U) Naval Operational Liaison

4.8.1 (U) Occasional liaison visits to the AN/FPS-112(XN-1) site will be requested of OPTEVFOR personnel. The purpose of the visits would be (1) to provide recommendations for radar data plotting and display techniques and (2) to assist in communicating with naval units during fleet and/or air exercises. Personnel assigned by OPTEVFOR should be qualified to provide the above assistance.

5.0 (U) ENVIRONMENTAL MEASUREMENTS

5.1 (U) Data-Gathering Periods

5.1.1 (U) Data-gathering periods must encompass all seasons of the year and all times of the day for each season to provide adequate statistical data to evaluate the radar system performance. With a weekly work schedule of 40 hours, and a requirement that most of the site personnel are needed to operate the system, it then becomes imperative to shift the working hours. One method is proposed. A four-week cycle will be repeated throughout fiscal '74, and the cycle will consist of one week with working hours 0800 to 1630, the next week 1630 to 2400, the next week 2400 to 0800 and the last of the cycle returned to 0800 to 1630. By this means data may be obtained at all times of day for all seasons within the 40-hour work week.

5.2 (U) Illumination Areas

5.2.1 (U) A sufficient number of target areas shall be selected within the antenna coverage, perhaps a total of 9 areas. An attempt will be made to illuminate each of the selected areas four times per day with actual observation times of about 5 to 6 minutes per area. The four times shall include midnight, noon, and the transitional periods of sunrise and sunset. The times of sunrise and sunset will be determined for midpath at the ionospheric height. The sequence may be shifted to observe a different target area coverage at the transitional times for each of the five days. The actual times of observations will be coordinated with the 40-hour work schedule.

5.3 (U) Measurements

5.3.1 (U) At each illumination attempt real-time measurements will be made of clutter level, noise level, signal amplitude and meteor responses. If the clutter spectrum can be resolved, the doppler frequencies and amplitudes of the approach and recede gravity waves and the stationary return near zero doppler shall be recorded. Tabulations of this data will be made to cover the year period for each of the nine coverage areas and include:

(1) percent of time coverage is obtained
(2) clutter level
(3) noise level
(4) SNR of the largest target return present
(5) clutter and noise spectra, and
(6) Probability of Detection (PD) and/or false alarm rate.

It is obvious that definitions must be established for the relationship between clutter level, noise level, etc., that indicate suitable illumination.

5.4 (U) Recordings and Data Reduction

5.4.1 (U) The full period of radar illumination shall be recorded on the HDR.

5.4.2 (U) Statistical data reduction will be made off-line from the HDR tape playback and computer analysis. Considerably more data can be extracted by off-line computer analysis and can be presented in very useful formats.

5.4.3 (U) The results of both on-line and off-line analysis will provide an answer to the percent of time specific target areas may be illuminated, average clutter levels, ambient noise and interference levels as a function of system look angle, and probability of detection with a given definition.

6.0 (U) TARGET DETECTION AND TRACKING-SURVEILLANCE

6.1 (U) Aircraft Targets

6.1.1 (U) Initial observations will be made with targets of opportunity. Several sources of information provide a means to locate such targets and to identify some of the aircraft (A/C) flights in real time. Correlation of radar tracking data will, in most other cases where possible, be made at a later time (within 30 days) from flight strips that will subsequently become available.

6.1.2 (U) The ability to identify aircraft flights that consist of multiple aircraft or to determine the number of aircraft in such a flight

will depend upon the resolution capabilities of the radar system. Trials will be made to observe multiple aircraft flights as targets of opportunity, but this is one area where accurate information is required and few civilian flights may be expected. Special efforts will be made to obtain advance information for military flights of two or more aircraft and requests will be made for dedicated flights of two to four aircraft so that observations may be made for controlled flight conditions.

6.1.3 (U) An HF communication system will be operated at the AN/FPS-112 (XN-1) site for direct communication with military test A/C to allow real-time correlation of radar data with A/C positions.

6.1.4 (U) Records will be kept of A/C detection trials to allow determination of the percent success or failure to detect and track the intended target. The signal levels and SNR's are of particular interest and should be related to the type of target. The probable cause of each failure or marginal detection shall always be recorded.

6.1.5 (U) At the onset of target tracking a time period shall be devoted each day to tracking A/C targets to build a catalog of return signal amplitudes vs target types and other variables. Tests shall compare SNR's of the correlator with that of the doppler analyzer with conditions optimized for each. The usefulness of the doppler, range, and azimuth data shall be evaluated with respect to detecting, tracking, and identifying targets. As the A/C detection catalog is accumulated, the time devoted to A/C tracking may be reduced to perform other tasks.

6.2 (U) Ship Targets

6.2.1 (U) Establish the criteria for ship detection. This will include doppler resolution required for various operating frequencies, minimum radial target velocities, target sizes, and MTI or non-MTI requirements.

6.2.2 (U) Determine the utility of the doppler offset mode of operation.

6.2.3 (U) Explore the feasibility of installing a beacon on the test ship.

6.2.4 (U) Observe ship targets when known movements occur either for a single ship of significant size or for multiple ship movements.

6.3 (U) Missile Targets

6.3.1 (U) Compute target characteristics in terms of radial range, velocity, acceleration and azimuth for anticipated types to be observed. Predict target characteristics at significant phases during the missile flight.

6.3.2 (U) Prepare a starting set of radar operating parameters to allow for possible short advance notice to launches.

6.3.3 (U) There is no provision for requesting dedicated missile launches as part of the AN/FPS-112(XN-1) T&E Program, but observations will be attempted when the notice of a pending launch is received. A dedicated A/C may be scheduled to fly a flight contour resembling a cruise missile characteristic.

6.4 (U) Fleet Exercises

6.4.1 (U) Fleet exercises will be observed when they occur. Specific data of interest will be the tracking of A/C with respect to a ship's position. Detection of both A/C and ships will be attempted.

7.0 (U) BEACON

7.1 (U) Procurement

7.1.1 (U) A beacon will be supplied by the contractor for installation within the area of radar coverage to be used for calibrating and monitoring the radar system performance. A prospective site at Ramey Air Force Base, P. R., has been selected for its installation.

7.1.2 (U) Delivery of the beacon is scheduled for 1 November 1973, but installation at the earliest available date will materially aid in both the radar system calibration and the continued monitoring of the radar system performance.

7.2 (U) Site Preparations

7.2.1 (U) Advance site preparations are required to provide power, air conditioning, and shelter for the beacon and other equipment. The beacon installation will also include installation of the beacon antenna.

7.3 (U) Beacon Checkout

7.3.1 (U) Test the beacon performance. Determine that the phase-coded signals received from the AN/FPS-112(XN-1) radar adequately trigger the beacon response at all operating frequencies. This shall be performed at several times of day to observe operation at several frequencies that may be used to illuminate the beacon site. The results shall be compared with previous bench tests to insure that the beacon sensitivity is adequate at all beacon frequencies. Measure the beacon output power and verify that the antenna is adequately matched to the beacon output and that the actual transmitted power is adequate. Observe the output waveform by pickup from the antenna and assure that the transmitted waveform and output frequency are correct.

7.4 (U) System Calibration Using Beacon

7.4.1 (U) The beacon will be used to calibrate the radar system in range, azimuth, sensitivity and doppler.

7.4.1.1 (U) The known ground range to the beacon site will be directly compared with a ground range calculated from the radar outputs to assess the method of calculation. This assessment will be made for all possible modes of beacon site illumination over an extended time period of several months.

7.4.1.2 (U) The beacon will also be used to provide azimuthal calibrations of the radar system. The deviations from the known true azimuth to the beacon site will be measured with the system monopulse and recorded with the best accuracy available over an extended period of several months. Periodic monitoring after that period of recording should be made to note any unexpected variations.

7.4.1.3 (U) Amplitude calibration will be obtained on a relative basis by recording signal amplitudes for variations of propagation mode, frequency, time of day, and season. Changes in propagation path loss will be noted with respect to the originally recorded signal returns. Calculations shall be made of predicted signal amplitudes using the known values of beacon output power, antenna gain, range, and a comparison made with actual received signal levels to obtain path loss. These shall also be compared with path loss calculations obtained by relating actual sea clutter return amplitudes with values calculated with the sea scatter coefficient.

7.4.1.4 (U) Propagation-induced shifts of doppler return frequencies may be monitored in a non-MTI mode or a doppler offset mode of operation. It may be more convenient to measure the beacon frequency offset than to obtain the same data from other methods such as clutter return doppler variations.

7.4.1.5 (U) The above beacon observations shall be included with the environmental tests, section 5.0, when the installation is completed.

8.0 (U) VEDEE

8.1 (S/NF) The VEDEE, a covert communication device for transmitting from the remote location to the radar site, is scheduled for delivery near the end of 1973. It will be installed at the Ramey Air Force Base site as early as possible. Tests shall be conducted to determine its message word rates, reliability, and its effect upon the capability of the radar during periods of communication.

9.0 (U) TARGET DETECTION - TACTICAL APPLICATION

9.1 (U) Tactical applications of the AN/FPS-112(XN-1) radar will depend upon (1) the target detection confidence factor, (2) the designating of targets of interest from other targets and (3) the timely reporting of significant detections and target parameters to fleet users.

9.1.1 (U) The confidence factor will be developed through the preceding period of target tracking and correlation with known A/C flight records.

9.1.2 (U) Separation of targets of interest from other targets will be more of a problem. The techniques generated will depend upon the radar capabilities that have been demonstrated. For example, target path and direction relative to a ship may be identifiable if the radar sensitivity, range resolution, doppler resolution, and azimuth accuracy are adequate. Thus, these techniques will need to be developed after system capabilities have been demonstrated.

9.1.3 (S) Techniques for timely reporting to the users may be partially accomplished by use of existing information channels. However techniques using the broadcast communication MODEM and VEDEE remain to be developed after their performance is demonstrated.

9.1.4 (U) The target detection and tactical application is an area of evaluation that can make valued use of fleet exercises, ship movement information, and dedicated A/C flights.

10.0 (U) BROADCAST COMMUNICATION

10.1 (U) The MODEM will be installed at Ramey AFB when the MODEM and site are available but not later than 15 January 1974.

10.2 (S) Tests of word rate, reliability, and radar performance during communicating intervals shall be made.

10.3 (S) The MODEM shall then be installed on a ship, preferably at Roosevelt Roads, P. R., for checkout and also for actual communications from the radar site to the ship during fleet exercises.

11.0 (U) DOCUMENTATION - PRESENTATION OF RESULTS - REPORTS

11.1 (U) HDR Recordings

11.1.1 (U) Produce HDR recordings of all significant radar operation periods and establish a tape library with a suitable filing system. Provide a 30-day supply of magnetic tapes and save most tapes for at least 30 days unless they are known to be faulty or of no further use.

11.1.2 (U) Maintain a current record of data contained on the existing tapes; note especially significant events and the quality of the on-line detections and tracking. This can be done with a card filing record.

11.2 (U) Log of On-Line Detections

11.2.1 (U) A log will be maintained of on-line detections.

11.2.2 (U) Establish a log of detection attempts with percent of success and failure and an assessment of probable cause for each failure. (See 6.1.3).

11.2.3 (U) Provide a current summary giving the areas of radar coverage (1) where identifiable detections are most likely, and (2) where detections will be of best use for FAD or bistatic operation.

11.3 (U) Photographs

11.3.1 (U) Provide at least one set of photographs showing real target detections as they appear on each of the displays. A second set may show simulated targets.

11.3.2 (U) Provide glossy 8 x 10 photos of the completed AN/FPS-112 (XN-1) site installation. Include transmit antenna, receive antenna, site transmitter building, site receiver building, transmitter HPA's and control room, and operations room. Provide photos of the Ramey beacon installation when completed.

11.4 (U) Plotting Board

11.4.1 (U) Install required communication line from the radar operator to the plotter.

11.4.2 (U) Conduct a practice exercise in the use of the plotting board to familiarize operators with its use and establish a satisfactory procedure for a good demonstration when scheduled.

11.5 (U) Operating and Maintenance Logs

11.5.1 (U) Logs shall be maintained for (1) radar operational parameters identified by time and date, and (2) for equipment failure and maintenance records.

11.6 (U) Reports

11.6.1 (U) Monthly reports will be submitted each month not later than 30 days following the end of the month. These reports will be an EPL responsibility but NRL personnel will assist in their preparation and editing.

11.6.2 (U) The Naval Research Laboratory will write a final report that will include a summary of the year's T&E results, recommendations of system changes, requirements for other site applications, assessment of suitability, and recommendations for possible use for the bistatic application.

12.0 (U) TEST AND EVALUATION SCHEDULE

12.1 (S) The original test schedule is shown on Fig. 1 with the updated version on Fig. 2. It was necessary to modify the original schedule for several reasons such as:

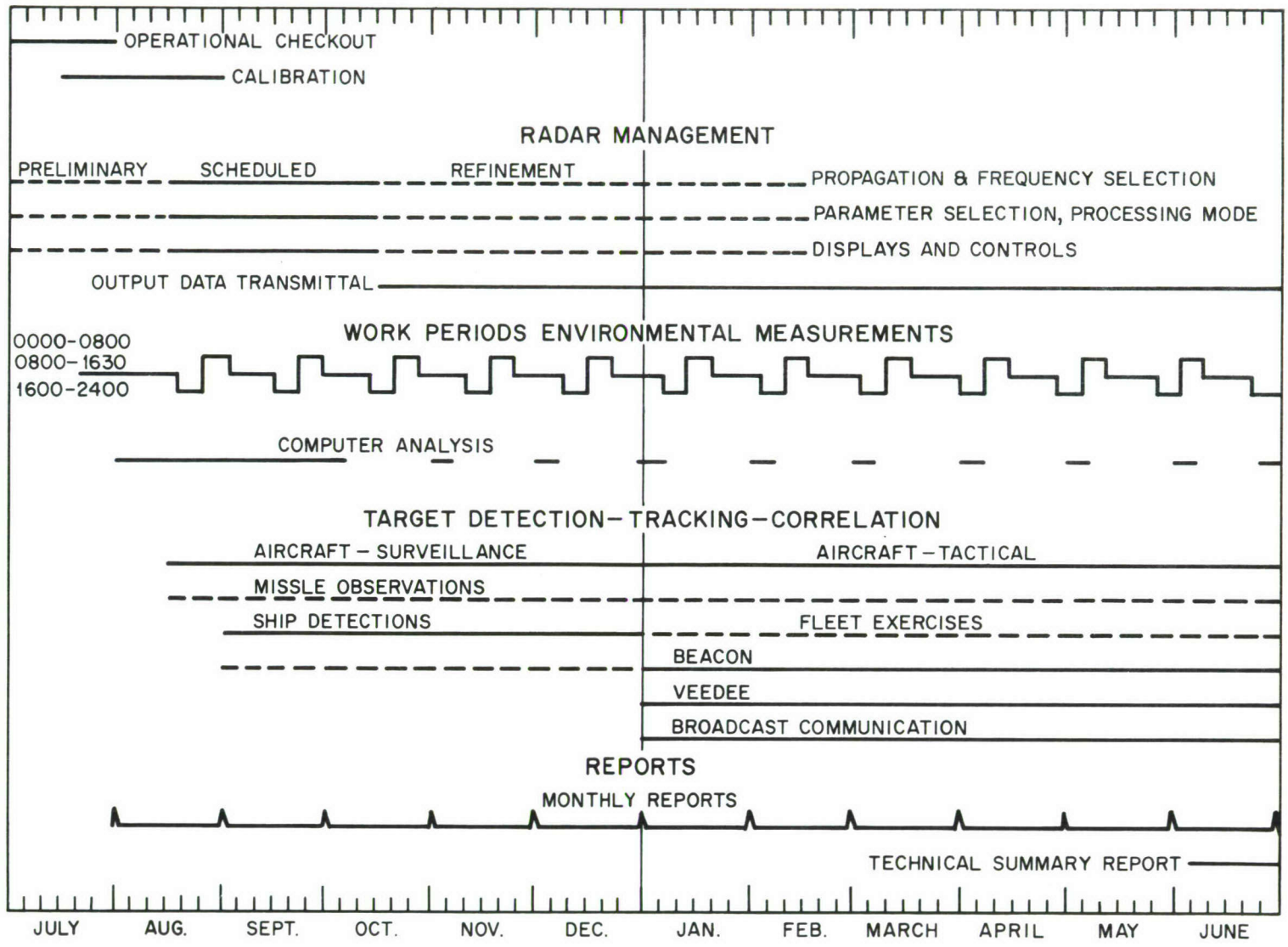
(a) The radar system installation and checkout was not completed by 1 July 1973 as originally scheduled, and some display problems still remain;

(b) A special period of data taking was performed at the request of NAVELEX from 15 August to 15 September to demonstrate satisfactory radar performance to DDR&E in order to obtain the release of deferred problem funds;

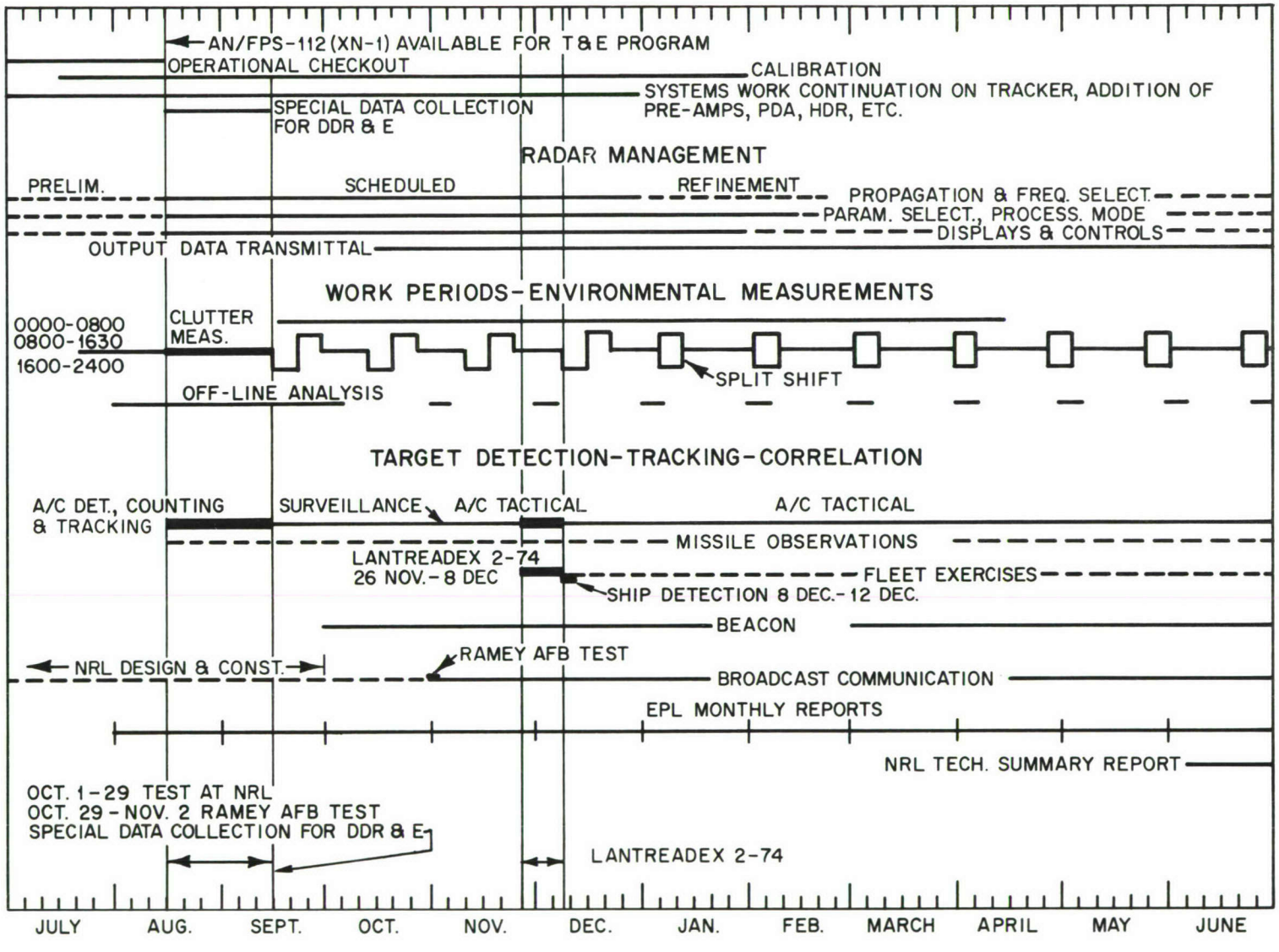
(c) The opportunity to participate in a Fleet Exercise (LANTREADEX 2-74) at an earlier time in the schedule than originally planned caused an advance in the beacon and the broadcast communication installation and operation schedules, and

(d) The possibility to perform the environmental measurements on a more efficient split work shift schedule became available.

12.2 (U) It is anticipated that some further modifications of the test plan schedule will be required to conform to requirements of the detailed test procedures.



(S) Figure 1



(S) Figure 2